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On the Positions of the Radcliffe Catalogue. By T. H. Safford, Assistant at the Observatory of Harvard College.

(*Communicated by Prof. Bond.*)

The differences given by the editor, the Rev. R. Main (*Radcliffe Catalogue*, p. v.) between the *Radcliffe* and the *Twelve-Year Catalogue*, can be approximately represented by the following formula:—

$$\text{Diff. of R.A. (Green. 12-Year C.}-\text{Rad.)} = -0^{s}{\cdot}038 + 0^{s}{\cdot}032 \sin (\alpha + 5^{h}\,32^{m}),$$

where α is the Right Ascension.

The remaining discrepancies are

R.A.	(Form.—Obs.)	R.A.	(Form.—Obs.)	R.A.	(Form.—Obs.)
h	s	h	s	h	s
0	+0·006	8	−0·004	16	−0·004
1	−0·007	9	−0·011	17	−0·016
2	+0·050	10	+0·024	18	−0·008
3	+0·024	11	+0·021	19	−0·009
4	−0·032	12	+0·030	20	+0·008
5	−0·030	13	+0·011	21	+0·005
6	−0·018	14	+0·004	22	0·000
7	−0·017	15	−0·030	23	+0·013

These remaining differences, although in some instances large, do yet change sign very frequently, and it will be observed that their mean between 10^{h} and 15^{h} is only $+0^{s}{\cdot}010$, whereas the mean of the original discrepancies deduced by Mr. Main between the same limits was $0^{s}{\cdot}05$ after subtracting the difference ($0^{s}{\cdot}038$) of equinoxes.

In investigating the causes which would give rise to such systematic discrepancies, I was first struck with the fact that

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the same, or nearly the same, variations were apparent in the assumed places of the time-stars, for years since 1845; that, if correct positions of time-stars had been assumed, the resulting positions would have been free from these small errors.

To prove this it is only necessary to adduce the comparisons made.

Denoting by A the positions (for Radcliffe time-stars) of the *Twelve-Year Catalogue* for 1845; by B, the assumed places for the same year (*Radcliffe Observations*, vol. vi. p. vii.) of the same stars; and by C, the results of that year's observations at the Radcliffe Observatory, we have on the average:—

Hours of R.A.	B—A.	C—B.	C—A.	No. Stars.	No. Obs.
0 to 9	+0·019	−0·002	+0·017	43	174
10 ,, 15	+0·074	−0·000	+0·064	15	62
16 ,, 23	+0·023	−0·001	+0·025	36	118

The weights given to the numbers in the second and third columns only, are proportional to the number of observations. The discrepancy is apparent enough, but it is nearly the same in C as B; showing that the observations of 1845 neither increased nor diminished to any sensible amount the discrepancy which already existed in the places of the time-stars. There is a slight casual non-agreement between (B — A) + (C — B) and (C — A), owing to the different weights allowed.

So far as the second column (C—B) is concerned, a similar investigation showed much the same results for every year between 1840 and 1844. The year 1840, it is true, gave a value of about $+0^s{\cdot}015$ between 10^h and 15^h for C—B. This probably contributed somewhat to the variations apparent in the time-stars of the following years, but a similar amount did not again appear; but the *Nautical Almanac* places for 1840, compared with the *Twelve-Year Catalogue* places for the same year, exhibit the following differences in the mean:—

Hours.	B—A.
0 to 9	+0·077
10 ,, 15	+0·093
16 ,, 23	+0·083

This, so far as it is not constant, is entirely owing to the proper motions of the *Nautical Almanac* stars, which were generally neglected until 1848.

These yearly proper motions are, on the average (making that of stars for which they were taken into account in 1840 = 0):—

Hours.	s
0 to 9	+0·004
10 ,, 15	+0·001
16 ,, 23	+0·004

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so that this error, which is contained in the Radcliffe time-stars, may have increased the variations in question.

In fact there is a tendency, in all proper motions in R.A., to be less (positively) between 10^h-15^h, or about these limits, than for other right ascensions; so that, not only the places of *Nautical-Almanac* stars, but those of other stars, will be somewhat erroneous, systematically, in this way, if computed without proper motion.

But why can errors of this kind remain, as we have seen that they do, in the results of observations? It would seem that they must be diminished by observing many stars together, and correcting their right ascensions mutually.

Suppose that N time-stars are observed in one day; that their right ascensions are a, $a+\beta$, $a+\beta'$, &c., and that these stars are equally used for the clock-errors. If a discrepancy of the form

$$m + n \sin a + p \cos a$$

exist, its effect upon the clock-errors for that day will be

$$m + \frac{n\,\{\sin a + \sin(a+\beta) + \sin(a+\beta') + \&c.\}}{N}$$

$$+ p\,\frac{\{\cos a + \cos(a+\beta) + \cos(a+\beta') + \&c.\}}{N};$$

or, expanding

$$m + n \sin a\,\frac{(1 + \cos\beta + \cos\beta' + \&c.)}{N}$$

$$+ p \cos a\,\frac{(1 + \cos\beta + \cos\beta' + \&c.)}{N}$$

$$- p \sin a\,\frac{(\sin\beta + \sin\beta' + \&c.)}{N}$$

$$+ n \cos a\,\frac{(\sin\beta + \sin\beta' + \&c.)}{N};$$

and this will be a resulting error in the observed place, for that night, of the star whose right ascension is a.

Let the same star be observed again, in other groups. The mean of all the quantities represented by $\sin\beta$ will be very nearly $= 0$; because every time-star will be compared with many stars on each side of it, so that many of the quantities represented by β will be positive, and many negative.

But, on the other hand, if β be always small (less than

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6 hours in almost all cases), the value of its cosine will be positive, and that of $\frac{1 + \cos \beta + \cos \beta' + \&c.}{N}$ will be nearly $= 1$, including, as it must, many instances in which the stars compared are within an hour or two of each other.

The effect of this will be (as we have seen in the *Radcliffe Observations*) to perpetuate any small systematic discrepancy of this kind.

But systematic differences depending on the declination tend to destroy themselves, unless the form of the pivots of the transit-instrument be erroneous.

I am, however, disposed to lay most stress upon the observed fact that the results of the *Radcliffe Observations* do, so far as the discrepancy in question is concerned, agree essentially with the assumed places of time-stars.

Hence it does not seem probable that the discrepancies in question have arisen from any instrumental error or error of observation, at least to the amount which they have reached.

Mr. Auwers, of Königsberg, has given (*Astr. Nachr.*, No. 1300) the following formula for correcting the Radcliffe *declinations*, so as to make them agree with Wolfers' *Tabulæ Reductionum*:—

$$\Delta \delta = -4''\!\cdot\!27 + 0''\!\cdot\!0647\, \delta^{\circ}.$$

I have tabulated these values with changed sign, so as to make them apply to N.P.D., and placed opposite them Mr. Johnson's own corrections:—

N.P.D.	Formula, Auwers.	Mr. Johnson's Correction.
°	"	"
0	−1·55	+0·92
10	−0·91	+1·03
20	−0·26	+1·15
30	+0·39	+1·28
40	+1·04	+1·38
50	+1·68	+1·46

These differ largely, and it is perhaps doubtful whether Mr. Auwers intended his formula to apply within 30° N.P.D. On the other hand, Wolfers' investigation (*Astr. Nachr.*, No. 1181) shows a general agreement between the Radcliffe *corrected* places and his own declinations.